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Veröffentlichungsversion / Published Version
Zeitschriftenartikel / journal article

Scientific Research and Essays Vol. 4 (13), pp. 1575-1590, December, 2009
Available online at http://www.academicjournals.org/SRE
ISSN 1992-2248 © 2009 Academic Journals

Standard Review

Virtual R & D teams in small and medium enterprises: A literature review

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Accepted 21 December, 2009

Small and medium enterprises (SMEs) are the driving engine behind economic growth. While SMEs play a critical role in generating employment and supporting trade, they face numerous challenges, the prominent among them are the need to respond to fasting time-to-market, low-cost and rapid solutions to complex organizational problems. Towards that end, research and development (R & D) aspect deserves particular attention to promote and facilitate the operations of SMEs. Virtual R & D team could be a viable option. However, literature shows that virtual R & D teaming in SMEs is still at its infancy. This article provides a comprehensive literature review on different aspects of virtual R & D teams collected from the reputed publications. The purpose of the state-of-the-art literature review is to provide an overview on the structure and dynamics of R & D collaboration in SMEs. Specifying the foundation and importance of virtual teams, the relationship between virtual R & D team and SMEs has been examined. It concludes with the identification of the gaps in the existing literatures and calls for future research. It is argued that setting-up an infrastructure for virtual R & D team in SMEs still requires a large amount of engineering efforts and deserves consideration at top level management.

Key words: Virtual teams, small and medium enterprises, literature review.

INTRODUCTION

SMEs are a major part of the industrial economies (Eikebrokk and Olsen, 2007; Robles-Estrada and Gomez-Suarez, 2007). Their survival and growth have therefore been a prominent issue. Beck et al. (2005) found that a strong and positive association between the growth of SMEs and GDP per capita growth. Their survival depended on their capability to market response, meeting performance and producing goods that could meet international standards (Gomez and Simpson, 2007). Organizations are currently facing unprecedented challenges in an ever dynamic, constantly changing and complex environment (Rezgui, 2007). It is urgent for SMEs to construct a network service platform to speed up the research and development process (Lan et al., 2004). ICTs are indispensible for SMEs to innovate (Redoli et al., 2008). Web resource services can help the enterprises to get external service resources and implement collaborative design and manufacturing (Dong and Liu, 2006).

Responding to the increasing de-centralization and globalization of work processes, many organizations have responded to their dynamic environments by introducing virtual teams. Virtual teams are growing in popularity (Wayne F. Cascio, 2000). Additionally, the rapid development of new communication technologies such as the Internet has accelerated this trend so that today, most of the large organizations employ virtual teams to some degree (Hertel, Geister and Konradt, 2005). Research on virtual teams is still in its nascent stages (Badrinarayanan and Arnett, 2008; Prasad and Akhilesh, 2002) and because of the relative newness of virtual teams, many areas of research have not been examined (Badrinarayanan and Arnett, 2008). Camarinha-Matos and Afsarmanesh (2003) conclude that, setting-up an infrastructure for virtual team still requires a large engineering effort, which represents a

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Abbreviations: SMEs, Small and medium enterprises; **R & D,** research and development; **ICTs,** information and computer technologies.

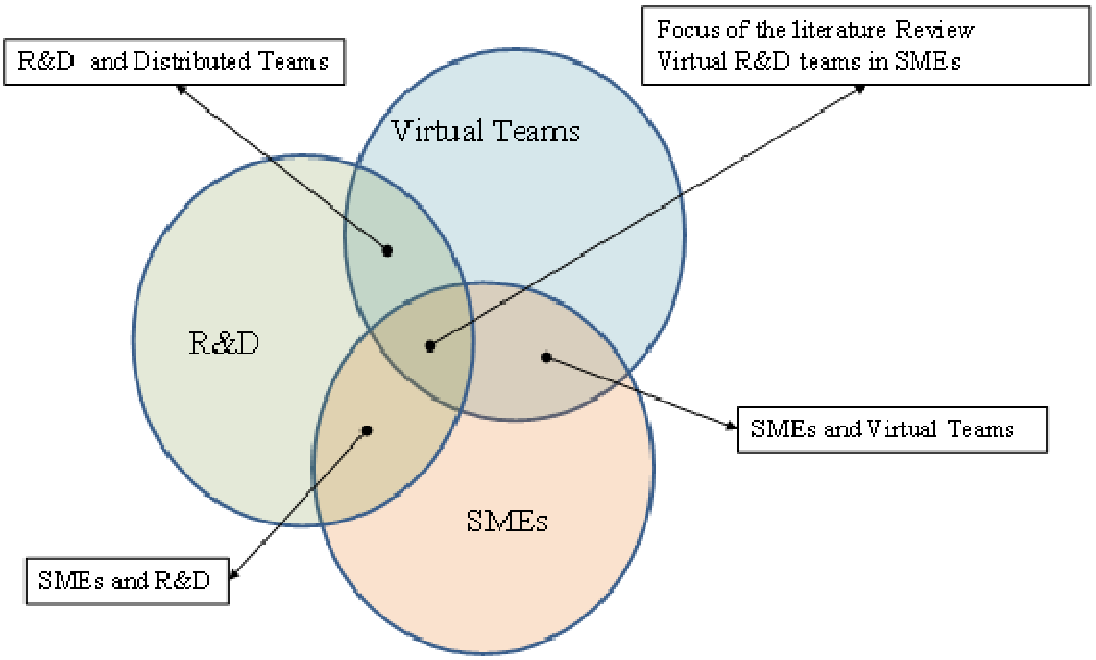

Figure 1. Literature fields included in the review - A general model.

major obstacle for the implantation of this new paradigm. Effective and efficient cooperation across disciplines and distributed teams becomes essential for the success of engineering projects (Zhang et al., 2008). Therefore, the experiments suggest that more research is needed to explore the ways to enhance the performance of virtual teams (El-Tayeh et al., 2008).

A small number of studies exclusively focused on the virtual R & D teams, for example (Gassmann and von Zedtwitz, 1999, 2003b; Kratzer et al., 2005; Tribe and Allen, 2003) and few of them concentrated on the virtual R & D teams in SMEs. This paper summarizes the key finding of precedent works on different aspects of virtual R & D teams in SMEs. It highlights the gaps and weaknesses in the existing literature on virtual R & D teams in SMEs. Finally, it identifies the future research directions in the area of concern.

LITERATURE SEARCH METHODOLOGY

Virtual R & D activities involving SMEs has not wide coverage. This review article is based on reliable and reputed publications that tried to accomplish the gaps. It mainly covers aspects like SMEs characteristics, scope of virtual R & D teams and their relationship with SMEs. The articles are collected from the following two sources:

1. Reputed journals, books and practitioners' literatures related to the topic published since 1997.
2. Research papers presented in a variety of conferences focusing on R & D and SMEs activities and technology management issues.

As there is no single definition of virtual R & D team in SMEs, there is a lack of specific research on the subject. A few studies have been done on virtual R & D teams in multinational companies. Hence, in order to find out structures, dynamics and management intervention in the field, a broader spectrum of literature has been considered. This review covered literatures in the areas of virtual R & D in general and its relevance with SMEs. The current understanding and thinking about SMEs and virtual R & D teams is found at the intersection of these separate fields, as illustrated in Figure 1.

The list of references contains approximately 194 items out of 537 selected items which were extracted from 1,425 pre-investigated items. To find relevant academic publications, some multidisciplinary databases were used. In order to find the relevancy a set of key words from a general model which is shown in Figure 1 were used. The general model for SMEs and virtual R & D teams enables a systematic integration of the fragmented literature on the topic. There is no consensus in the literature whether virtual teams are superior for SMEs or not. We argue that lack of SMEs will be sheltered by virtual teams.

The trend of publication shows that virtual R & D team in SMEs is an interesting topic in recent years. As an example, the distribution of published/citied articles per year extracted from Web of Science® data base is illustrated in Figure 2 to Figure 7.

VIRTUAL TEAMS: ORIGIN, TRENDS AND DEFINITION

While work teams were used in the U.S. as early as the

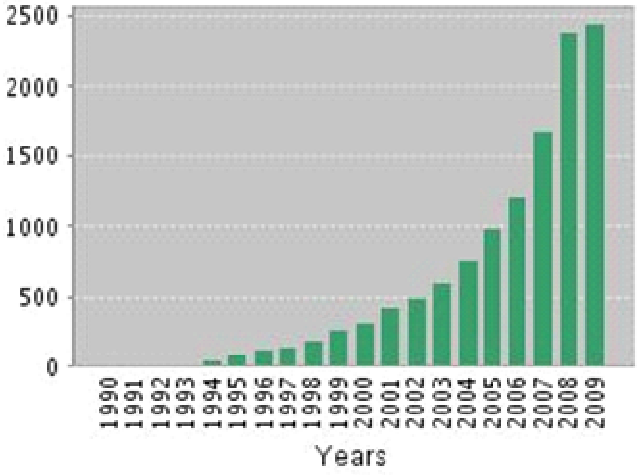

Figure 2. Citations trend of "SMEs" (Source Web of Science® (2009)).

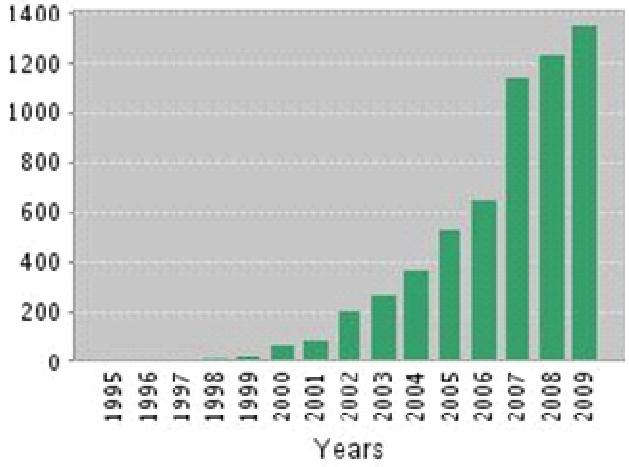

Figure 3. Citations trend of "Virtual teams" (Source Web of Science® (2009)).

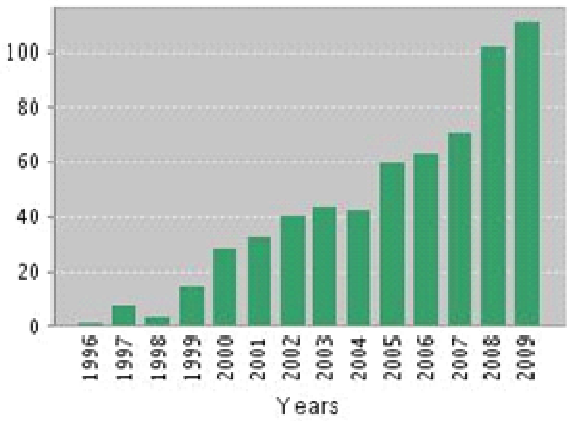

Figure 4. Citations trend of "SMEs and R & D" (Source Web of Science® (2009)).

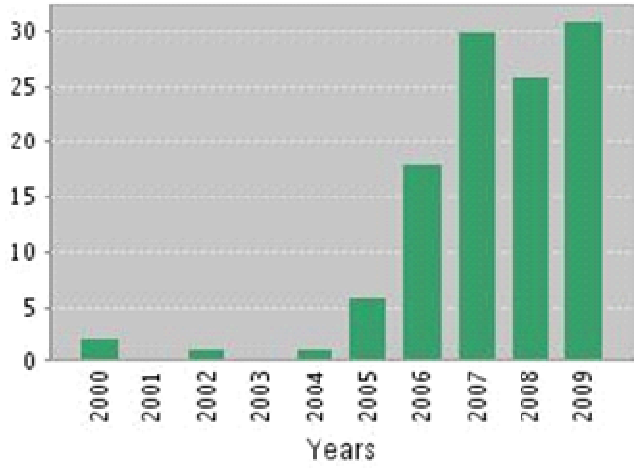

Figure 5. Citations trend of “R & D and Distributed Teams” (Source Web of Science® (2009)).

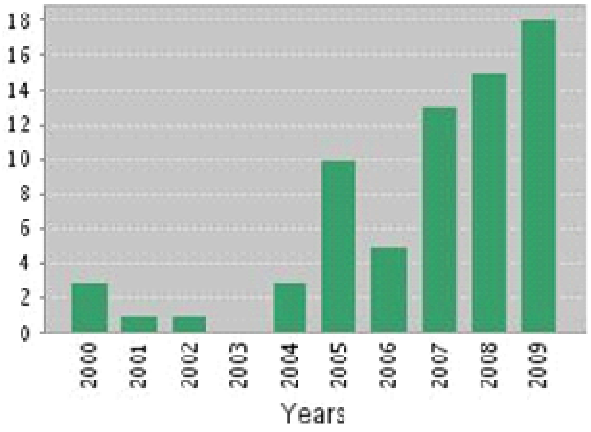

Figure 6. Citations trend of "Virtual R & D teams" (Source Web of Science® (2009)).

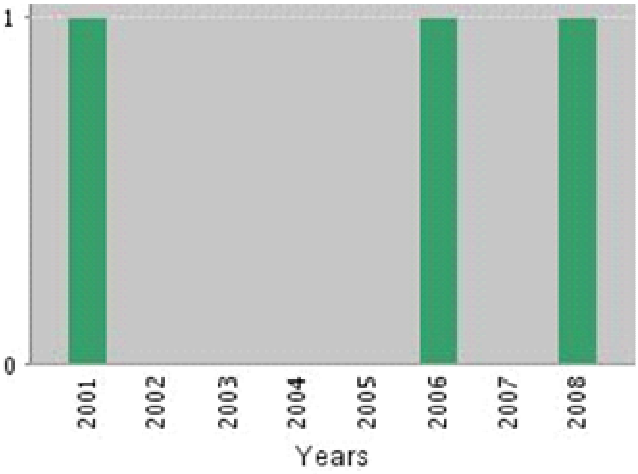

Figure 7. Article publications trend of "SMEs and Virtual R & D teams" (Source Web of Science® (2009)).

1960s, the widespread use of teams and quality circles began in the Total Quality Management movement of the 1980s. In the late 1980s and early 1990s, many companies implemented self-managing or empowered work teams. To cut bureaucracy, reduce cycle time and improve service, line-level employees took on decision-making and problem-solving responsibilities traditionally reserved for management. By the mid-1990s, increasing numbers of companies such as Goodyear, Motorola, Texas Instruments and General Electric had begun exporting the team concept to their foreign affiliates in Asia, Europe and Latin America to integrate global human resource practices (Kirkman et al., 2001). Now, due to communication technology improvements and continued globalization, virtual teams have increased rapidly worldwide (Kirkmann et al., 2002). This era is growing popularity for virtual team structures in organizations (Cascio, 2000; Walvoord et al., 2008). Martins et al. (2004) in a major review of the literature on virtual teams, conclude that 'with rare exceptions all organizational teams are virtual to some extent.' We have moved away from working with people who are in our visual proximity to working with people around the globe (Johnson et al., 2001).

Definition of Virtual Team

Literature related to virtual teams revealed a lack of depth in the definitions. Although virtual teamwork is a current topic in the literature on global organizations, it has been problematic to define what 'virtual' means across multiple institutional contexts (Chudoba et al., 2005). The concept of a "team" is described as a small number of people with complementary skills who are equally committed to a common purpose, goals and working approach for which they hold themselves mutually accountable (Zenun et al., 2007). It is worth mentioning that virtual teams are often formed to overcome geographical or temporal separations (Cascio and Shurygailo, 2003). Virtual teams work across boundaries of time and space by utilizing modern computer-driven technologies. The term "virtual team" is used to cover a wide range of activities and forms of technology-supported working (Anderson et al., 2007). Virtual teams are comprised of members who are located in more than one physical location. This team trait has fostered an extensive use of a variety of forms of computer-mediated communication that enable geographically dispersed members to coordinate their individual efforts and inputs (Peters and Manz, 2007).

Gassmann and Von Zedtwitz (2003b) defined "virtual team as a group of people and sub-teams who interact through interdependent tasks guided by common purpose pose and work across links strengthened by information, communication and transport technologies." Another definition suggests that virtual teams, are distributed work teams whose members are geographically dispersed and coordinate their work, predominantly with electronic information and communication technologies (e-mail, video-conferencing, telephone, etc.) (Hertel et al., 2005), different authors have identified diverse. From the perspective of Leenders et al. (2003), virtual teams are groups of individuals collaborating in the execution of a specific project while geographically and often temporally distributed, possibly anywhere within (and beyond) their parent organization. Lurey and Raisinghani (2001) defined virtual teams - groups of people who work together although they are often dispersed across space, time and/or organizational boundaries. Amongst the different definitions of the concept of a virtual team the following form is one of the most widely accepted: (Powell et al., 2004), ''we define virtual teams as groups of geographically, organizationally and/or time dispersed workers brought together by information technologies to accomplish one or more organization tasks''.

The degree of geographic dispersion within a virtual team can vary widely from having one member located in a different location than the rest of the team to having each member located in a different country (Staples and Zhao, 2006). Along with Bal and Teo (2001) it could be concluded that a team will become virtual if it meets four main common criteria and other characteristics that are summarized in Table 1. Geographically dispersed teams allow organizations to hire and retain the best people regardless of location. The temporary aspect of the team appears less emphasized (Lee-Kelley and Sankey, 2008) although (Bal and Teo, 2001; Paul et al., 2005; Wong and Burton, 2000) included 'temporary' in virtual team definition but some authors like Gassmann and Von Zedtwitz (2003b) use, 'may be temporary' for some team members.

A summary of the definition of a virtual team may be taken as: small temporary groups of geographically, organizationally and/ or time dispersed knowledge workers who coordinate their work predominantly with electronic information and communication technologies in order to accomplish one or more organization tasks.

Advantages and disadvantages of virtual teams

During the last decade, words such as "virtual", "virtualization", "virtualized" have been very often advocated by scholars and practitioners in the discussion of social and economic issues (Vaccaro et al., 2008) but the advantages and pitfalls of a virtual team is concealed. The availability of a flexible and configurable base infrastructure is one of the main advantages of agile virtual teams. Anderson et al. (2007) suggest that the effective use of communication, especially during the early stages of the team's development, plays an equally important role in gaining and maintaining trust. Virtual team may allow people to collaborate with more productivity at a distance (Gassmann and Von Zedtwitz, 2003a). As a drawback,

Table 1. Common criteria of virtual team.

Characteristics of virtual team	Descriptions	References
Common criteria	Geographically dispersed (over different time zones)	(Dafoulas and Macaulay, 2002; Lee-Kelley and Sankey, 2008; Nemiro, 2002; Peters and Manz, 2007; Shin, 2005; Wong and Burton, 2000).
	Driven by common purpose (guided by a common purpose)	(Bal and Teo, 2001; Gassmann and Von Zedtwitz, 2003b; Hertel et al., 2005; Rezgui, 2007; Shin, 2005).
	Enabled by communication technologies	(Bal and Teo, 2001; Lee-Kelley and Sankey, 2008; Nemiro, 2002; Peters and Manz, 2007)
	Involved in cross-boundary collaboration	(Bal and Teo, 2001; Gassmann and Von Zedtwitz, 2003b; Precup et al., 2006; Rezgui, 2007).
Other characteristics	It is not a permanent team	(Bal and Teo, 2001; Cascio and Shurygailo, 2003; Leenders et al., 2003; Paul et al., 2005; Wong and Burton, 2000).
	Small team size	(Bal and Teo, 2001).
	Team member is knowledge workers	(Bal and Teo, 2001; Kirkman et al., 2004).
	Team members may belong to different companies	(Dafoulas and Macaulay, 2002; Leenders et al., 2003).

virtual teams are particularly weak at mistrust, communication break downs, conflicts and power struggles (Rosen et al., 2007). On the other hand, virtual teams reduce time-to-market (May and Carter, 2001). Lead Time or Time to market has been generally admitted to being one of the most important keys for success in manufacturing companies (Sorli et al., 2006). Table 2 summarizes some of the main advantages and Table 3 some of the main disadvantages associated with virtual teaming. Finally, organizational and cultural barriers are another serious impediment to the effectiveness of virtual teams. Many managers are uncomfortable with the concept of a virtual team because successful management of virtual teams may require new methods of supervision (Jarvenpaa and Leidner, 1999).

Forming and performing in virtual teams is useful for projects that require cross-functional or cross boundary skilled inputs and the key to their value creation is to have a defined strategy in place to overcome the issues highlighted, especially the time zones and cultural issues. While communication could be seen as a traditional team issue, the problem is magnified by distance, cultural diversity and language or accent difficulties. For migration or similar large-scale projects, personal project management competency, appropriate use of technology and networking ability, willingness for self-management, cultural and interpersonal awareness is the fundamentals of a successful virtual team (Lee-Kelley and Sankey, 2008).Thomas and Bostrom (2005) found that a technology facilitator role can be critically important to virtual team success.

RESEARCH AND DEVELOPMENT (R & D) AND DISTRIBUTED TEAM

Nowadays, unpredictable economic and business environment suggests that many firms seek new ways of conducting their business through some kind of innovation to make a profit and stay ahead of the competition (Laforet, 2007). Around the world, innovation is now recognized as a prime source of competitive advantage (Hegde and Hicks, 2008). Research and development is a strategy for developing technologies that can be commercialized under independent intellectual property rights. R & D enables firms to create new technologies and/ or to build on existing technologies obtained through technology transfer (Zhouying, 2005). R & D activities are now dependent to different location drivers (von Zedtwitz and Gassmann, 2002). Many firms started to acquire their knowledge from external sources (Erkena and Gilsing, 2005). R & D units in foreign countries have gained more responsibilities and competencies besides the still-existing traditional mode of product developed

Table 2. Some of the main advantages associated with virtual teaming.

Advantages	References
Reducing relocation time and costs, reduced travel costs (Virtual teams overcome the limitations of time, space and organizational affiliation that traditional teams face (Piccoli, Powell and Ives, 2004))	(Bergiel et al., 2008; Biuk-Aghai, 2003; Boudreau et al., 1998; Cascio, 2000; Kankanhalli et al., 2006; Lipnack and Stamps, 2000; Liu and Liu, 2007; McDonough et al., 2001; Olson-Buchanan et al., 2007; Prasad and Akhilesh, 2002; Rice et al., 2007).
Reducing time-to-market [Time also has an almost 1:1 correlation with cost, so cost will likewise be reduced if the time-to market is quicker (Rabelo and Jr., 2005)]	(Chen, 2008; Ge and Hu, 2008; Gunis et al., 2007; Kankanhalli et al., 2006; Kusar et al., 2004; Lipnack and Stamps, 2000; May and Carter, 2001; Mulebeke and Zheng, 2006; Prasad and Akhilesh, 2002; Shachaf, 2008; Sorli et al., 2006; Sridhar et al., 2007; Zhang et al., 2004).
More effective R & D continuation decisions	(Cummings and Teng, 2003; Schmidt et al., 2001).
Most effective and rapid in making decisions	(Bal and Gundry, 1999; Hossain and Wigand, 2004; Paul et al., 2004).
Able to tap selectively into the center of excellence, using the best talent regardless of location	(Badrinarayanan and Arnett, 2008; Boudreau et al., 1998; Boutellier et al., 1998; Cascio, 2000; Criscuolo, 2005; Fuller et al., 2006; Furst et al., 2004; Prasad and Akhilesh, 2002; Samarah et al., 2007).
Greater degree of freedom to individuals involved with the development project	(Badrinarayanan and Arnett, 2008; Ojasalo, 2008; Prasad and Akhilesh, 2002).
Greater productivity, shorter development times	(McDonough et al., 2001; Mulebeke and Zheng, 2006).
Producing better outcomes and attract better employees, Generate the greatest competitive advantage from limited resources.	(Chen et al., 2008; Martins et al., 2004; Rice et al., 2007).
Useful for projects that require cross-functional or cross boundary skilled inputs	(Lee-Kelley and Sankey, 2008).
Higher degree of cohesion (Teams can be organized whether or not members are in proximity to one another)	(Cascio, 2000; Gaudes et al., 2007; Kratzer et al., 2005).
Provide organizations with the unprecedented level of flexibility and responsiveness	(Chen, 2008; Gunis et al., 2007; Hunsaker and Hunsaker, 2008; Liu and Liu, 2007; Piccoli et al., 2004; Pihkala et al., 1999; Powell et al., 2004; Prasad and Akhilesh, 2002).
Self-assessed performance and high performance.	(Chudoba et al., 2005; Poehler and Schumacher, 2007).
The extent of informal exchange of information is minimal (virtual teams tend to be the more task oriented and exchange less socio emotional information	(Pawar and Sharifi, 1997; Schmidt et al., 2001).
Respond quickly to changing business environments	(Bergiel et al., 2008; Mulebeke and Zheng, 2006).
Improve communication and coordination and encourage the mutual sharing of inter-organizational resources and competencies	(Chen et al., 2008).
Sharing knowledge, experiences; Facilitate knowledge capture	(Furst et al., 2004; Lipnack and Stamps, 2000; Merali and Davies, 2001; Rosen et al., 2007; Sridhar et al., 2007; Zakaria et al., 2004).

Table 2. Contd.

Provide a vehicle for global collaboration and coordination of R & D-related activities	(Paul et al., 2005).
Enable organizations to respond faster to increased competition	(Hunsaker and Hunsaker, 2008; Pauleen, 2003).
Better team outcomes (quality, productivity and satisfaction)	(Gaudes et al., 2007; Ortiz de Guinea et al., 2005; Piccoli et al., 2004).
Higher team effectiveness and efficiency	(May and Carter, 2001; Shachaf and Hara, 2005).

Table 3. Some of the main disadvantages associated with virtual teaming.

Disadvantages	References
Sometimes requires complex technological applications	(Badrinarayanan and Arnett, 2008; Bergiel et al., 2008)
Decrease monitoring and control of activities	(Pawar and Sharifi, 1997).
Weak at mistrust, communication break downs, conflicts and power struggles	(Baskerville and Nandhakumar, 2007; Cascio, 2000; Kirkman et al., 2002; Rosen et al., 2007; Taifi, 2007).
Challenges of project management are more related to the distance between team members than to their cultural or language differences	(Badrinarayanan and Arnett, 2008; Jacobsa et al., 2005; Martinez-Sanchez et al., 2006; Wong and Burton, 2000).
Challenges of determining the appropriate task technology fit	(Badrinarayanan and Arnett, 2008; Bell and Kozlowski, 2002; Griffith et al., 2003; Ocker and Fjermestad, 2008; Pawar and Sharifi, 2000; Qureshi and Vogel, 2001).
Challenges of managing conflict	(Hinds and Mortensen, 2005; Kayworth and Leidner, 2002; Ocker and Fjermestad, 2008; Piccoli et al., 2004; Ramayah et al., 2003; Wong and Burton, 2000).
Cultural and functional diversity in virtual teams leads to differences in the members' thought processes. Develop trust among the members are challenging	(Badrinarayanan and Arnett, 2008; Bell and Kozlowski, 2002; Boutellier et al., 1998; Griffith et al., 2003; Jacobsa et al., 2005; Kankanhalli et al., 2006; Munkvold and Zigurs, 2007; Paul et al., 2005; Poehler and Schumacher, 2007; Shachaf, 2005).

adapted in the home country and technical support for production in abroad (Reger, 2004). Trends in the last decade has shown China and India emerging as attractive R & D destinations for the USA (Hegde and Hicks, 2008).

Changes in telecommunications and data processing capabilities make it possible to coordinate research, marketing and production operation around the world (Acs and Preston, 1997). Hegde and Hicks (Hegde and Hicks, 2008) noted that overseas R & D sites are auxiliary outposts, subservient to home R & D laboratories. "Corporate growth and positioning" and "knowledge sourcing" are two forces which result in companies with a more global R & D nature (Richtne´r and Rognes, 2008). Technological change is a highly dynamic process that may quickly relocate to take the advantage of optimum conditions for growth (Hegde and Hicks, 2008). For most R & D teams', being virtual is a matter of degree (Leenders et al., 2003).

SMEs: DEFINITION, IMPORTANCE AND MAJOR CHARACTERISTICS

There are many accepted definitions of SMEs and the classifications vary from industry to industry and from

country to country (O'Regan and Ghobadian, 2004). Different countries adopt different criteria such as employment, sales or investment for defining small and medium enterprises (Ayyagari et al., 2007). At present, there seems to be no consensus on the definition for SMEs (Deros et al., 2006). Table 4 illustrate the definition of SMEs in some selected countries..In the absence of a definitive classification, a consensus has developed around the European Commission (EC) criteria for SME classification (O'Regan and Ghobadian, 2004). This definition adopts a quantitative approach emphasizing "tangible" criteria, employee numbers (up to 250 employees), turnover and balance sheet statistics (Tiwari and Buse, 2007). While turnover and balance sheet statistics are part of the criteria, the overriding consi-deration in practice appears to be employee number based. Even if all three criteria were afforded equal consideration, it could be argued that the definition fails to take into account the attributes of a modern day small to medium-sized firm.

The importance of Small and medium size enterprises (SMEs)

Small and Medium Enterprises (SMEs) play an important role to promote economic development. Acs et al. (1997) concluded that small firms are indeed the engines of global economic growth. In most countries, SMEs dominate the industrial and commercial infrastructure (Deros et al., 2006). More importantly, SMEs play an important role in flows of foreign direct investment (FDI) (Kuo and Li, 2003). Economists believe that the wealth of nations and the growth of their economies strongly depend upon their SMEs' performance (Schroder, 2006). In many developed and developing countries, SMEs are the unsung heroes that bring stability to the national economy. They help buffer the shocks that come with the boom and bust of economic cycles. SMEs also serve as the key engine behind equalizing income disparity among workers (Choi, 2003). China's recent rapid growth is also linked to the emergence of many new small firms in village townships and in coastal areas, often named new industries (Acs et al., 1997).

To survive in the global economy SMEs have to improve their products and processes exploiting their intellectual capital in a dynamic network of knowledge-intensive relations inside and outside their borders (Corso et al., 2003). Hanna and Walsh (2002) observed that if small firms want to make a step-change in their technological and innovation base, they have to rethink their approach to cooperation. SMEs need appropriate and up-to-date knowledge in order to compete and there is a strong need to create, share and disseminate knowledge within SME's (Nunes et al., 2006). Especially, in the emerging and dynamic markets the shared knowledge creation and innovation may speed up market development (Blomqvist et al., 2004). The key elements in knowledge sharing are not only the hardware and software, but also the ability and willingness of team members to actively participate in the knowledge sharing processes (Rosen et al., 2007). Dickson and Hadji-manolis (Dickson and Hadjimanolis, 1998) examined innovation and networking among small manufacturing companies. They found some tentative evidence that companies operating in terms of "the local strategic network" are more innovative than those operating in terms of "the local self-sufficiency". In the beginning of R & D activities, SMEs always face capital shortage and need technological assistance.

Most firms today do not operate alone; they are networked vertically with many value-chain partners (Miles et al., 2000). The typical Taiwanese production system has a cooperative network of SMEs that are extremely flexible and quick responsive, although under-capitalized and sensitive to market demand and highly integrated in the global economy (Low, 2006). Strategic alliance formation mechanism has been touted as one of the most critical strategic actions that SMEs must undertake for survival and success (Dickson et al., 2006). Gassmann and Keupp (2007) found that managers of SMEs should invest less in tangible assets, but more in those areas such as R & D that will directly generate their future competitive advantage.

The major characteristics of SMEs

In order to have a better understanding of SMEs behavior, a brief knowledge of the characteristics of SMEs is a must and therefore the major characteristics of SMEs are listed in Tables 5 and 6 (these are for all types of SMEs and not all may hold true for every SME). SMEs are not scaled-down versions of large companies. There are different characteristics that distinguish them from large corporations and that can, of course, change across different countries and cultures. SMEs are generally independent, multi-tasking, cash-limited and owner-based actively managed by the owners, highly personalized and informal structured, largely localized enterprises in their area of operations that are largely dependent on internal sources to the growth of finance (Perrini et al., 2007).

VIRTUAL R & D TEAMS IN SMES

Most SMEs are heavily reliant on external sources, including customers and suppliers, for the generation of new knowledge (Jones and Macpherson, 2006). SMEs of all sizes must reach out into their external environment for necessary resources (P. H. Dickson et al., 2006). In the present era of globalization, it is obvious that the survival of the SMEs will be determined first and foremost

Table 4. Definition of SMEs in Selected countries.

Country	Category of enterprise	Employee numbers	Turnover	Other measures	Source
European Commission	Small	10 - 50 employees	Less than € 10 million turnover	Balance sheet total :Less than € 10 million balance sheet total	(Fathian et al., 2008).
	Medium	Fewer than 250 employees	Less than € 50 million turnover	Balance sheet total :Less than € 43 million balance sheet total	(Fathian et al., 2008).
Japan		Up to 300 employees		¥100 million assets	(Deros et al., 2006).
Indonesia	Small	5 - 19		annual value of sales of a maximum of IDR1 billion (USD100,000)	(APO, 2007).
	Medium	20 - 99		annual value of sales of more than IDR1 billion but less than IDR50 billion	(APO, 2007).
Iran	Small	Less than 10* Less than 50**			*(CBI, 2009). **(ISIPO, 2009).
	Medium	10 - 100* 50 - 250**			*(CBI, 2009). **(ISIPO, 2009).
Malaysia	Small	Between 5 and 50 employees	Between RM 250,000 and less than RM 10 million		(NSDC, 2005).
	Medium	51 - 300employees	Between RM 10 million and RM 25 million		(NSDC, 2005).
Philippines	Small	10 - 99 employees.		Between PHP 3-15 million asset	(APO, 2007)
	Medium	100 - 199 employees.		Between PHP 15-100 million asset	(APO, 2007)
South Korea		Up to 300 employees			(Oh, Cruickshank and Anderson, 2009)
Tanzania	Small	5 - 50	150.0 million (Tshs)	Capital invested: 5.1-200.0 million(Tshs)	(Mahemba and Bruijn, 2003)
	Medium	51 - 100	300.0million (Tshs) Tshs = US$ 1.050 (2003)	Capital invested: 201-800.0 million(Tshs)	(Mahemba and Bruijn, 2003)
USA		fewer than 500		stand-alone enterprises	(Deros et al., 2006)

Table 5. Some of the major advantages of SMEs.

Advantages	References
Able to respond quickly to customer requests and market changes, customers focused	(Abdul-Nour et al., 1999; Canavesio and Martinez, 2007; Huang et al., 2004; Jones and Macpherson, 2006; Levy and Powell, 1998; Mahemba and Bruijn, 2003; Schatz, 2006; Wu et al., 2007).
Flexible and fast-response to change, easily adaptive to new market conditions, dynamic in behavior, developing customized solutions for partners and customers	(Abdul-Nour et al., 1999; Aragon-Sanchez and Sanchez-Marín, 2005; Davis and Sun, 2006; Deros et al., 2006; Levy and Powell, 1998; Mezgar et al., 2000; Narula, 2004; Nieto and Fernandez, 2005; Sarosa, 2007; Schatz, 2006; Starbek and Grum, 2002).
Quick decision making process (decisions are made by an individual or a small number of people, or a single individual)	(Axelson, 2005; Deros et al., 2006; Lawson et al., 2006; Schatz, 2006).
Strongly correlated and inter-related with respect to innovation and entrepreneurship	(Bodorick et al., 2002; Chew and Yeung, 2001; Gray, 2006; Gunasekaran et al., 1999; Huang et al., 2001; Robles-Estrada and Gomez-Suarez, 2007; Sharma and Bhagwat, 2006)
More extensive use of external linkages for Innovate.	(Barnett and Storey, 2000; Hoffman et al., 1998; Laforet and Tann, 2006).
Nonbureaucratic processes, flat and flexible structures	(Axelson, 2005, 2007; Deros et al., 2006; Haga, 2005; Levy and Powell, 1998; Massa and Testa, 2008; Schatz, 2006; Sharma and Bhagwat, 2006).
Strong inter and intra-firm relationships, managing a great amount of information	(Carbonara, 2005; Chen et al., 2007).
Good at multi-tasking	(Axelson, 2007; Schatz, 2006).
Capable of going international early and rapidly	(Gassmann and Keupp, 2007).
Productive	(Beck et al., 2005).
Knowledge creating	(Egbu et al., 2005; Levy et al., 2003).
Creating astute alliances, networking	(Dijk et al., 1997; Karaev et al., 2007; Kearney and Abdul-Nour, 2004; Massa and Testa, 2008; Partanen et al., 2008)

by their ability to manufacture and supply more, at competitive cost, in less delivery time, with minimum defects, using fewer resources (Sharma and Bhagwat, 2006). In order to face this challenge, SMEs can reinforce knowledge to create synergies that allow firms to overcome difficulties and succeed. This may lead to new relationships between different agents to overcome scarcity and/or difficulties in gaining access to resources (Gomez and Simpson, 2007).

The combination of explosive knowledge growth and inexpensive information transfer creates a fertile soil for unlimited virtual invention (Miles et al., 2000). Web resource services can help the enterprises to get external service resources and implement collaborative design and manufacturing (Dong and Liu, 2006). It is especially urgent for SMEs to construct a service platform of network to speed up the product development process (Lan et al., 2004). Sharma and Bhagwat (2006) study results revealed that information technology (IT) in SMEs is still in a backseat despite the fact that use of computers is continuously increasing in their operations.

Call for Virtual R & D Teams in SMEs

A global market requires a short R & D cycle; hence SMEs are also forced into shifting from sequential to concurrent product development. Virtual teams are dra-

Table 6. Some of the major disadvantages of SMEs.

Disadvantages	References
Scarce resources and manpower	(Abdul-Nour et al., 1999; Axelson, 2007; Caputo et al., 2002; Jansson and Sandberg, 2008; Kearney and Abdul-Nour, 2004; Kim et al., 2008; Lu and Beamish, 2006; Nieto and Fernandez, 2005; Partanen et al., 2008; Wang and Chou, 2008; Yusuff et al., 2005).
Limited degree of information technology (IT) implementation	(Egbu et al., 2005; Eikebrokk and Olsen, 2007; Lin et al., 2007; Sarosa and Zowghi, 2003; Sharma and Bhagwat, 2006; Wang and Chou, 2008).
Weak at converting research and development into effective innovation	(O'Regan et al., 2006).
Lacking some of the essential resources for innovation and severe resource limitations in R & D	(Dickson and Hadjimanolis, 1998; Hausman, 2005; Lee and Ging, 2007; Massa and Testa, 2008; Rolfo and Calabrese, 2003; Sharma and Bhagwat, 2006; Singh et al., 2008).
Not having formal R & D activities	(Adams et al., 2006; Bougrain and Haudeville, 2002).
Strategy formulation on the basis of what available, lack a long run perspective	(Gomez and Simpson, 2007; Lindman, 2002; Yusuff et al., 2005).
Lagging in the export, lack the resources necessary to enter foreign markets	(Jansson and Sandberg, 2008; Mahajar et al., 2006).
Lack of industrial engineers or right kind of manpower to apply various statistical and managerial methods or tools	(Ahmed and Hassan, 2003)

matically influencing organizations and employee virtual R & D in SMEs is not a choice but an obligation to reduce the time-to-market in the intensively competitive market environment. Along with the findings of Gassmann and Keupp (2007), advantages of virtual teams for SMEs are extracted and illustrated in Table 7. Managers of SMEs should invest less in tangible assets, but more in those areas that will directly generate their future competitive advantage such as R & D. Therefore, managers of SMEs should recognize that virtual teams are essential in modern organizations.

CONCLUSION

This paper is providing a comprehensive review on virtual R & D teams in SMEs in an effort to assess the state of the literature. Information and communication technology, although now is very popular but still not matured enough, so dealing with it can generate new findings. Currently, the topic suffers from limitation of coverage in almost all major publications as it is obvious in Figure 7. Although Virtual teams in SMEs can enhance the competitive flexibility of organizations, there are still considerable gaps in virtual R & D team efforts and effects within SMEs. A comprehensive empirical study would now seem to be important. Such a study would provide an assessment on patterns, practices, technology or types of activities that should be carried out by R & D virtual teams in SME's. It can further go into the probable and possible benefits and problems that arise as a consequence of the creation of virtual R & D team in SMEs.

While some studies have been conducted on usage of the certain model in large companies, applications within SMEs have still remained largely un-documented. This extensive review shows that limited work has been directed towards exploring and analyzing the existing inter-relation between virtual R & D teams and SMEs. Therefore empirical research on this important new type of team working shows tremendous promise for future research. Keeping virtual R & D teams in SMEs, operating innovatively, effectively and efficiently, is of a high importance, but the issue has poorly been addressed simultaneously in the previous studies. In many cases, virtual R & D teams can be used as an optional strategy for compensating the lack of resources among SMEs.

Managing virtual R & D teams in SMEs is a challenge. Some important challenges are development of trust

Table 7. Compensate lack of SMEs by virtual teams.

Disadvantage of SMEs	Can be compensated with advantage of virtual teams
Scarce resources and manpower	Able to tap selectively into the center of excellence, using the best talent regardless of location Reducing relocation time and costs, reduced travel costs Reducing time-to-market (Time has an 1:1 correlation with cost)
Lacking some of the essential resources for innovation, severe resource limitations in R & D Not having formal R & D activities limited degree of information technology (IT) implementation	More effective R & D continuation decisions Can manage the development and commercialization tasks quite well Sharing knowledge, experiences
Weak at converting research and development into effective innovation	Facilitating transnational innovation processes Higher team effectiveness and efficiency
Rely on outdated technology, labor intensive and traditional management practices	Respond quickly to changing business environments Most effective in making decisions Provide organizations with the unprecedented level of flexi-bility and responsiveness
Lagging in the export	Provide a vehicle for global collaboration and coordination of R & D-related activities

between team members, determining the appropriate task technology fit and establishing proper tools and systems to facilitate information sharing. Effective management can help a virtual R & D teams in SMEs to overcome the constraints imposed by applying virtual R & D team. Therefore, setting-up an infrastructure for virtual R & D team in SMEs still requires a large amount of engineering efforts, especially designing a proper collaborative system. Successful management of virtual teams requires new methods of supervision. Extensive research is needed to understand the characteristics of virtual R & D teams in SMEs. We believe our work provides a further step in this direction.

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